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EFFECTIVENESS EVALUATION OF CLUSTERS' FUNCTIONING**В.П. Ільчук**, д-р екон. наук**І.В. Лисенко**, канд. екон. наук

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ОЦІНЮВАННЯ РЕЗУЛЬТАТИВНОСТІ ФУНКЦІОНУВАННЯ КЛАСТЕРІВ**В.П. Ильчук**, д-р экон. наук**И.В. Лысенко**, канд. экон. наук

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ОЦЕНКА РЕЗУЛЬТАТИВНОСТИ ФУНКЦИОНИРОВАНИЯ КЛАСТЕРОВ

In this article proposes an integrated approach to the assessment of performance indicators functioning cluster as a complex socio-economic system, that allows to determine the performance of enterprises of cluster. A mathematical model for evaluating the performance of the cluster has been developed. Criteria conditions that contribute to the creation of clusters based on matrix interactions enterprises were identified. According to criteria have been defined enterprises that form the base cluster and reserve of enterprises, connected in appropriate way with the base enterprises of cluster.

Key words: cluster, enterprise, effect synergies, mathematical model, the structure of the cluster, algorithm, formation of scheme, members of the cluster.

Запропоновано комплексний підхід до оцінювання показників результативності функціонування кластера як складної соціально-економічної системи, який дозволяє визначити результативність підприємств кластерного утворення. Розроблено математичну модель оцінювання результативності роботи кластера. Визначено критеріальні умови, які сприяють створенню кластерів на базі матриці взаємодії підприємств. За встановленими критеріями визначено підприємства, які формують базу кластера, а також підприємства резерву, які певним чином взаємопов'язані з базовими підприємствами кластера.

Ключові слова: кластер, підприємство, синергетичний ефект, математична модель, структура кластера, алгоритм, схема формування, учасники кластера.

Предложен комплексный подход к оценке показателей результативности функционирования кластера как сложной социально-экономической системы, который позволяет определить результативность предприятий кластера. Разработана математическая модель оценки результативности работы кластера. Определены критеріальные условия, которые способствуют созданию кластеров на базе матрицы взаимодействия предприятий. По установленным критериям определены предприятия, которые формируют базу кластера, а также предприятия резерва, которые определенным образом взаимосвязаны с базовыми предприятиями кластера.

Ключевые слова: кластер, предприятие, синергетический эффект, математическая модель, структура кластера, алгоритм, схема формирования, участники кластера.

Problem. Lately, the number of scientific researches on the integration processes in the real economy, the results of which indicate that the geographical proximity of enterprises related activities provides more opportunities to improve their productivity and innovation are growing. Besides, the formation of sectoral and cross-sectoral integrated structures as a means of effective cooperation between different types of enterprises, ensuring efficient use of resources, regional industrial infrastructure and its own capacities are considered.

Based on the fact that the problem of development and innovation and technological development of production faces to Ukrainian producers rather acutely, perspective areas and effective techniques of the given problem requires solution. These problems can be solved by creating integrated organizations, which in their turn will help to consolidate efforts based on common opportunities of innovation introduction, namely to invest significant amounts of material, financial and human resources to the development of new technology and advanced technologies.

Analysis of recent researches and publications. Problems of functioning and development of cluster associations are reported in the works of leading foreign scientists, particularly in the works of M. Enright, S. Rosenfeld, D. Jacobs, W. Price, V. Banduryn, W. Gzhegozh, E. Lemmer, M. Keating, J. Clegg, M. Porter, D. Radeby, A. Ruhman, Paul Samuelson, George Soros, Uennop

Yu, D. Jacobs, L. Yang, N. and others, as well as national, M. Boiko E. Bezvushko, Z. Varnaliy, N. Vnukov, M. Voynarenko, N. Volkova, S. Mocherny, S. Sokolenko, V. Fedorenko, A. Melnyk, V. Zakharchenko, V. Chuzhykov and other prominent scientists who have contributed greatly to the development of the theory and practice of clustering economy.

Outlining the parts of the general problem not solved yet. However, the scientific studies have not found a proper reflection of the issues related to the development of an integrated approach to the evaluation of the effectiveness indicators functioning cluster as a complex socio-economic system that caused the topicality of this research.

The main material. The efficiency of the formation and inter-sectoral integrated structures in various industries as a means of effective cooperation between various types of enterprises and their cooperative efforts of modern production are considered, sustainable use of their production capacities and increase output. That is, the article deals with the formation of producer associations - clusters - to harmonize economic activities of their members, improve the efficiency of production and services, as newly established economic system for their participation provides favorable conditions for establishing competitive industries, the effective functioning of a particular commodity market and services [9].

The article [16] researches the clustering of regional economy and proposes management model the formation and functioning of clusters. To develop an integrated approach to the evaluation of effectiveness indicators functioning cluster is considered in detail the content of the stages of the algorithm evaluation of the functioning of cluster formation.

Step 1. Identifying a list of key indicators to evaluate the effectiveness of separate operating companies and companies that operate as part of cluster formation.

The main indicators to assess the effectiveness of selected indicators of the same name that could be applied for separately operating companies and for companies that operate as part of cluster formation.

A scheme integrated approach to the evaluation of effectiveness indicators functioning cluster formation as a complex socio-economic system is shown in Figure 1.

The list of specified evaluation effectiveness of the functioning of cluster formation is shown in Table 1.

Key indicators for evaluation of the functioning of enterprises cluster formation and businesses operating are independently presented in Table 2.

Step 2. The assessment of each parameter that characterizes the performance of the cluster and individual enterprises.

The important factor determines the importance of j-s indicators X_k^k , X_k^c to assess the impact of cluster formation in accordance businesses and individuals independently operating companies in the region. The number of factors importance corresponds to the number of parameters, but for any number of them the sum of all values equals to one:

$$\alpha_1 + \alpha_2 + \dots + \alpha_k + \dots + \alpha_N = 1. \quad (1)$$

Step 3. Selection of separate operating companies that are similar to companies involved in cluster formation.

Selection of enterprises are in the region where the researches are carried out and in other regions. Enterprises should have a similar production program (to produce similar products in its range and quality), is equal to the scale of production and have the same conditions for marketing and market size, which are supplied with products.

If some companies are selected as objects of study in order to compare with the companies participating in cluster formation, with slightly better effectiveness, then the benefits of enterprise cluster obtained a positive impact on the results of efficiency studies and testify clustering processes. If indicators of cluster formation in this case are much better than the sum of efficiently operating companies, it can be stated the high efficiency of cluster formation.

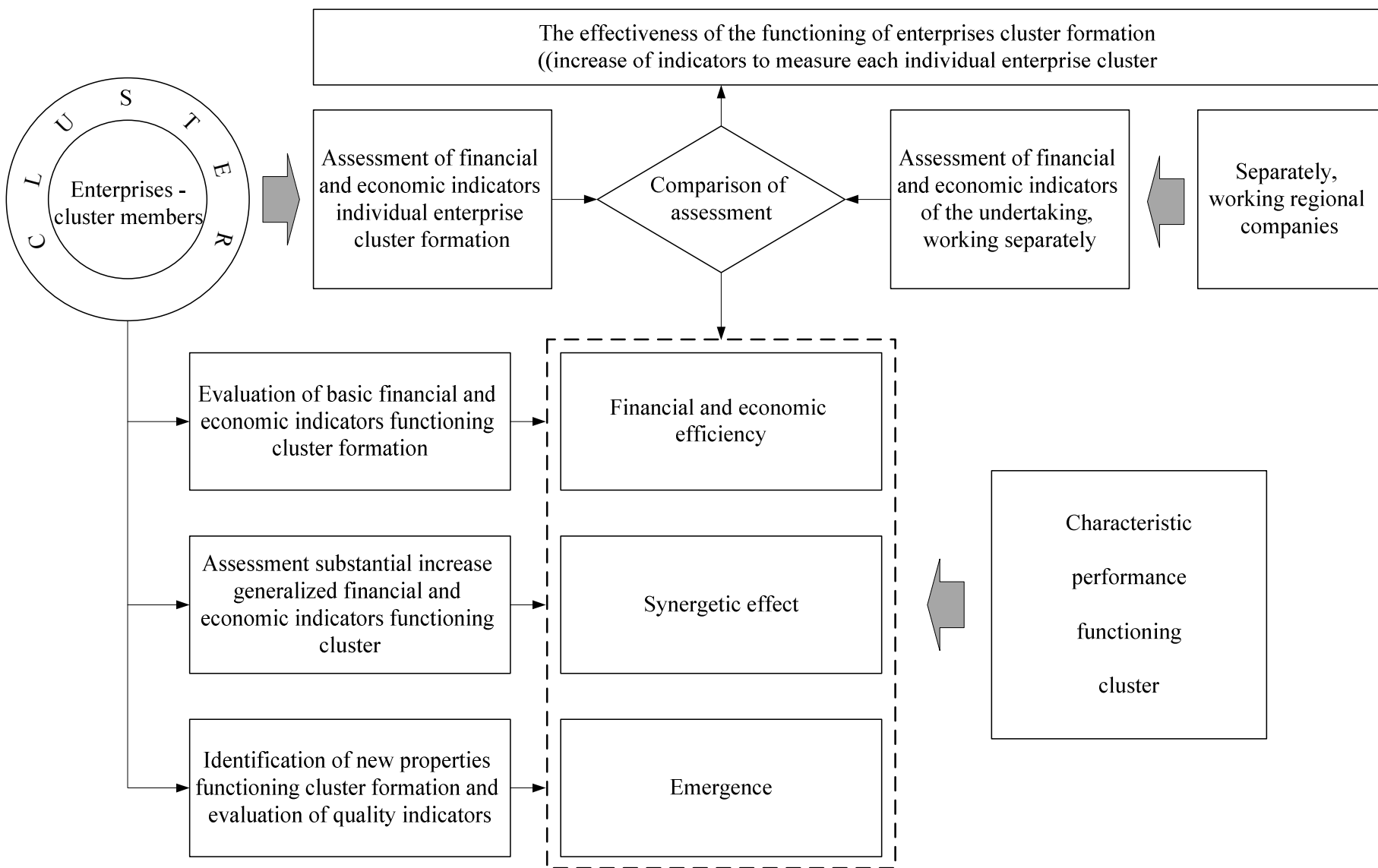


Fig. 1. An integrated approach to the assessment of performance indicators functioning as a complex cluster socio-economic system

Performance evaluation of the functioning of cluster

The main indices of separate operating companies and companies that operate as part of cluster	The main summary measure of cluster formation evaluation functioning as a system	New properties that cluster formation is getting as a system (effect emermanagement)
<ol style="list-style-type: none"> 1. Indicators profitability of enterprises <ul style="list-style-type: none"> Return on assets Yield implementation Return on investment 2. Indicators evaluation of liquidity, solvency and creditworthiness <ul style="list-style-type: none"> The value of working capital Coverage ratio Solvency ratio The duration of repayment of debts Turnover of tangible assets 3. Indicators evaluation of financial durability and stability <ul style="list-style-type: none"> Coefficient of autonomy Factor mobility equity Ratio of financial dependence 4. Performance evaluation of profitability <ul style="list-style-type: none"> Profitability of activity Profitability on sales Profitability on capital Profitability on equity Payback period equity 5. Indicators of business activity <ul style="list-style-type: none"> Turnover of working capital Receivables Turnover Turnover payable Assets of fixed assets 	<ol style="list-style-type: none"> 1. The total amount of products 2. The total amount of sales proceeds 3. Total return 4. The total profitability of 5. Cost of products 6. Productivity 7. materials' production 8. payback investments by day 9. The size of product markets 10. Total expenditure on marketing activities 11. Economy socially necessary costs in the operation of cluster formation 12. Technological upgrade production facilities of enterprises cluster 	<ol style="list-style-type: none"> 1. Create a strong association of image that can withstand external threats 2. The ability to promote their own ideas and strategies at local, inter-regional and national markets 3. Increasing capacity of mobilizing innovative investment and other resources to accelerate innovation of fixed assets 4. Accelerated effective management gain experience in all areas of management activities 5. More efficient use of natural and human resources and industrial infrastructure 6. Improving the competitiveness of products 7. Establishing effective socio-economic models of production

Table 2

The list of indicators for the evaluation of the functioning of enterprises cluster formation and businesses operating independently

№	Name of indicators to measure the performance of enterprises cluster and self-employed businesses	Coefficient gradient means bridge-performance α_j ($j=1...M$)	Performance indicators functioning enterprises													Effective-ness $R = \frac{X_i^k}{X_i^c}$	
			The total value of, $X^c = \sum_{k=1}^N X_k^c$	Value for self-employed businesses						The total value of, $X^k = \sum_{k=1}^N X_i^k$	Values for companies that operate as part of the cluster						
				1	2	...	k	...	N		1	2	...	k	...		N
1	Indicators profitability of enterprises	α_1	$X_1^c = \sum_{k=1}^N X_{1k}^c$	X_{11}^c	X_{12}^c	...	X_{1k}^c	...	X_{1N}^c	$X_1^k = \sum_{k=1}^N X_{1k}^k$	X_{11}^k	X_{12}^k	...	X_{1k}^k	...	X_{1N}^k	$R_1 = \frac{X_1^k}{X_1^c}$
	1.1 Return on assets	α_2	$X_2^c = \sum_{k=1}^N X_{2k}^c$	X_{21}^c	X_{22}^c	...	X_{2k}^c	...	X_{2N}^c	$X_2^k = \sum_{k=1}^N X_{2k}^k$	X_{21}^k	X_{22}^k	...	X_{2k}^k	...	X_{2N}^k	$R_2 = \frac{X_2^k}{X_2^c}$
	1.2 Yield implementation	α_3	$X_3^c = \sum_{k=1}^N X_{3k}^c$	X_{31}^c	X_{32}^c	...	X_{3k}^c	...	X_{3N}^c	$X_3^k = \sum_{k=1}^N X_{3k}^k$	X_{31}^k	X_{32}^k	...	X_{3k}^k	...	X_{3N}^k	$R_3 = \frac{X_3^k}{X_3^c}$
1.3 Return on investment																	
2	Performance assess the liquidity, solvency and creditworthiness	α_4	$X_4^c = \sum_{k=1}^N X_{4k}^c$	X_{41}^c	X_{42}^c	...	X_{4k}^c	...	X_{4N}^c	$X_4^k = \sum_{k=1}^N X_{4k}^k$	X_{41}^k	X_{42}^k	...	X_{4k}^k	...	X_{4N}^k	$R_4 = \frac{X_4^k}{X_4^c}$
	2.1 Size of the shareholder equity																
	...	α_j	$X_j^c = \sum_{k=1}^N X_{jk}^c$	X_{j1}^c	X_{j2}^c	...	X_{jk}^c	...	X_{jN}^c	$X_j^k = \sum_{k=1}^N X_{jk}^k$	X_{j1}^k	X_{j2}^k	...	X_{jk}^k	...	X_{jN}^k	$R_j = \frac{X_j^k}{X_j^c}$
	...																
5	Indicators of business activity.																
	5.4 Capital productivity of the main assets	α_M	$X_M^c = \sum_{k=1}^N X_{Mk}^c$	X_{M1}^c	X_{M2}^c	...	X_{Mk}^c	...	X_{MN}^c	$X_M^k = \sum_{k=1}^N X_{Mk}^k$	X_{M1}^k	X_{M2}^k	...	X_{Mk}^k	...	X_{MN}^k	$R_M = \frac{X_M^k}{X_M^c}$

Step 4. Identification of effectiveness indicators of individual enterprises and cluster formation.

Based on the fact that different effectiveness evaluation of the functioning of enterprises cluster formation and individual enterprises have different dimension ((HRV, %, and so on.), then the correct account in the mathematical model, they should lead to a dimensionless quantity. That is one indicator that is taken into account in the model, given the same name as the ratio of the values defined for enterprises cluster formation and for individual companies, such as return on assets affects:

X^k_j – for enterprise cluster formation;

X^c_j – for individual self-operating companies, are not included in cluster formation.

That is, using the model index "return on assets" $\frac{X^k_1}{X^c_1}$ is performed as a ratio that has no dimension. Similarly, reduced to dimensionless measurement and evaluation of other indicators.

Step 5. Development of mathematical models for evaluating the effectiveness of cluster formation.

A mathematical model for evaluating the effectiveness of the cluster formation based on certain effectiveness evaluation, the name and number of which is determined by the analyst, depending on the type of cluster formation, specialization of production and depth of research. In general, the mathematical model is:

$$\alpha_1 \frac{\sum_{k=1}^N X_{1k}^K}{\sum_{k=1}^N X_{1k}^c} + \alpha_2 \frac{\sum_{k=1}^N X_{2k}^K}{\sum_{k=1}^N X_{2k}^c} + \dots + \alpha_j \frac{\sum_{k=1}^N X_{jk}^K}{\sum_{k=1}^N X_{jk}^c} = H, \quad (2)$$

where α_j – importance factor j -th parameter estimation performance of the enterprise;

$\sum_{k=1}^N X_{jk}^K$ – the sum of the j -th evaluation index N companies that are part of the cluster;

$\sum_{k=1}^N X_{jk}^c$ – the sum of the j -th evaluation index N enterprises that operate independently;

k – ordinal value of the enterprise ($k = 1 \dots N$);

j – ordinal coefficient significance ($j = 1 \dots M$);

H – normative value of the performance of cluster formation, which determines whether the created cluster.

By marking certain expressions as follows:

$$\sum_{k=1}^N X_j^K = X_1^K, \quad \sum_{k=1}^N X_{jk}^c = X_1^c.$$

Equation (2) takes the form:

$$\alpha_1 \frac{X_1^K}{X_1^c} + \alpha_2 \frac{X_2^K}{X_2^c} + \dots + \alpha_j \frac{X_k^K}{X_k^c} = H. \quad (3)$$

Step 6. Calculation of identified indicators for evaluating the effectiveness of individual companies and cluster formation in general.

The product of cluster formation is an integral feature of the production of all participating enterprises cluster formation, which were integrated into a single production structure and

using certain organizational, economic, technical, technological and other benefits to increase their production capacity and competitiveness because its effectiveness evaluated as indicators single functional production system and can achieve a certain level assessment synergistic effect the operation of cluster formation.

Regarding the analysis of effectiveness of enterprises cluster formation and self-employed businesses, it is advisable to compare and evaluate their efficiency under different conditions of their production activities. The given researches to assess the effectiveness of cluster formation, the benefits of the new firm organizational and economic ties manufacturing companies and prospects of cluster formations. A tentative list of indicators to measure the performance of companies in different operating conditions, which is presented in Table 2 may be supplemented as necessary depth analysis.

Step 7. Determination of the relative effectiveness of the index cluster formation and overall level of functioning.

A well-functioning cluster usually has characteristics that exceed the performance operation of individual businesses operating autonomously, the ratio: $\frac{X_k^k}{X_k^c}$ must be greater than one that must be made for all parameters:

$$H = \alpha_1 \frac{X_1^k}{X_1^c} + \alpha_2 \frac{X_2^k}{X_2^c} + \dots + \alpha_j \frac{X_j^k}{X_j^c} > 1. \quad (4)$$

In exceptional cases where $H = 1$, cluster formation has no advantage over companies that operate separately. When functioning cluster formation when $H \leq 1$, it can break. However, the experience and practice of cluster formations functioning effectively working clusters always meet the requirements $H > 1$.

In the real functioning of cluster formations have every opportunity to maintain a high level of performance and to ensure sustainable economic growth of all its members.

The content of the third phase of the study of clustering regional economy "Algorithm streamline the membership of cluster formation" is shown in Figure 2.

Consider in detail the content of the stages of the algorithm organize the membership of cluster formation.

Step 1. Investigation revealed the structure of cluster formation.

Some enterprises by territorial criteria were included in the composition of cluster formation have different organizational, economic and technical and technological level of development and thus have different effects on the performance of his work. Using data from Table 2, we can determine those companies whose significance for the cluster is minimal.

For this pre-calculate the share of each parameter β enterprises participating in the total value of this parameter:

$$\beta = \frac{X_{jk}^k}{Y_j} = \frac{X_{jk}^k}{\sum_{k=1}^N X_{jk} / N}, \quad (5)$$

where X_{jk}^k – j -th indicator k -th member enterprises cluster;

$Y_j = \frac{\sum_{k=1}^N X_{jk}}{N}$ – the average value of the specified index of all participating companies included in cluster;

N – the number of participating enterprises cluster formation.

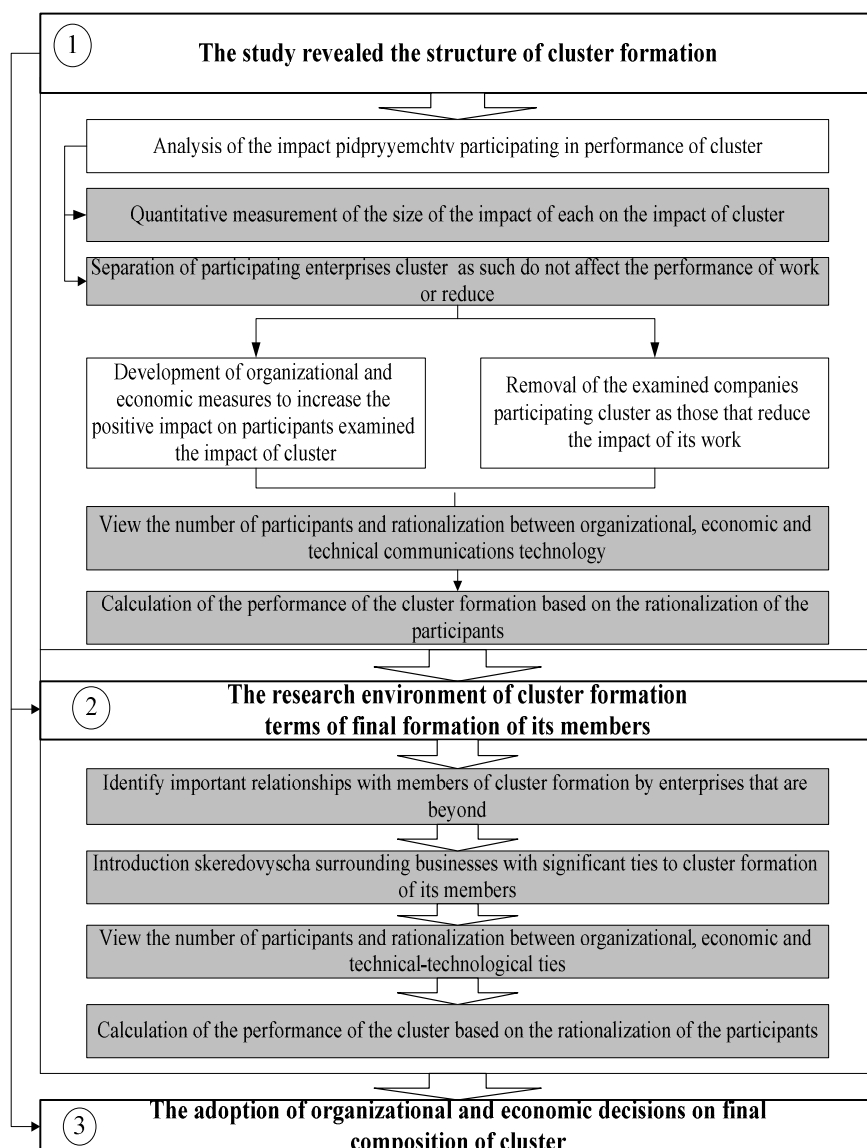


Fig. 2. Algorithm streamline the membership of cluster

In a situation where $\beta < 0,5 \cdot Y_j$ company partner under research has insignificant impact on this indicator on the effectiveness of cluster formation.

If this result takes place for the other indicators, such enterprise can be removed from the cluster formation as working inefficiently.

In further researches we assess those businesses that are close to the limit value. If $\beta \geq 0,5 \cdot Y_j$, it is advisable to leave the company as part of the cluster. If the value is accounted for indicators with a maximum weight coefficient value, it also solved the question of whether the participation of enterprises in cluster formation.

These researches and appropriate measures allow to streamline the number of participating companies formally included in the cluster by territorial criterion [10].

If the goal is to leave the company discovered that work ineffectively, as part of cluster formation, we developed a number of organizational and economic measures to improve their effectiveness. Otherwise, these enterprises are excluded from the number of cluster formation. For the evaluation of the structural changes in the cluster formation, check out the

performance of its operations for the relation (5). Enabling enterprises in cluster formation may extend slightly beyond.

Step 2. Research environment cluster formation in terms of the final formation of its members.

Separation by territorial boundaries of the cluster criterion covers along with effectively operating companies and businesses that are not appropriate to include in the cluster formation due to ineffective activity. However, outside of the cluster can be in companies that are successfully have established productive relationships with companies that are included in cluster formation. Hence it is advisable to revise the structure of cluster formation participants to complement it effectively working enterprises which simultaneously have effective relationships with members of cluster formation.

Procedure for assessment of their impact on the effectiveness of the operation of cluster formation is similar to the previous one, at which ineffective enterprises are excluded. This should draw attention to the clustering criteria that have maximum weight value and correspond to the enterprise that increases the possibility of its entrance in cluster formation.

After performing these steps structural changes and the formation of cluster members accepted an informed decision about its formation and final calculated the impact of its operations on the basis of the changes.

Conclusions and suggestions. A comprehensive approach to the assessment of effectiveness indicators functioning cluster as a complex socio-economic system that allows businesses to determine the impact of cluster formation. A mathematical model for evaluating the effectiveness of the cluster. Supportive modeling involves determining criterion conditions that contribute to the creation of clusters based on matrix interactions enterprises. According to criteria defined businesses that form the base cluster and enterprise allowance in some way linked to the underlying enterprise cluster.

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